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(54) PROCESS FOR PHOTOGRAPHICALLY PRINTING AN IMAGE ON A SURFACE OF AN OBJECT

(71) We, FABRIQUE NATIONALE HERSTAL S.A., en abrégé FN, a body corporate organized and existing under the laws of Belgium, of 4400 Herstal-lez-Liège, Belgium, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process for photographically printing an image on a non-developable (as hereinafter defined) surface of an object.

The term non-developable is used in this specification in a geometrical sense as denoting a surface which is not capable of being flattened out, without stretching of any element, upon a plane, and the term object in this specification includes metal articles and ceramic articles, for example of glass, crystal, porcelain, and such objects may be utilitarian or decorative. The material of the articles may be opaque or transparent.

According to the present invention, there is provided a process for photographically printing an image on a non-developable (as hereinbefore defined) surface of an object, which process comprises coating said surface with a photosensitive polymer, subjecting the photosensitive polymer coating to the action of light through an exposure mask provided between said coated surface and a transparent casing wherein the object is enclosed, the exposure mask being pressed into intimate contact with said coating over the whole area thereof by a pressing force which is applied to the exposure mask by the casing and which is produced by a reduced pressure within the casing, and subsequently dissolving away the more soluble parts of the photosensitive polymer coating.

The choice of photosensitive polymer is dictated by the article in question, the chemical nature of the surface on which the image is to be printed and, to a certain extent, the fineness of the image details to be reproduced.

The surface of the object on which the image is to be printed may be covered with a reflection-preventing varnish prior to the step of applying the photosensitive polymer coating. As an alternative to the reflection-preventing varnish, the polymer coating may contain colouring matter which renders it opaque.

A process which is not in accordance with the invention but which is included herein by way of explanation, and a process according to the present invention, will now be described by way of example with reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic exploded view of a device for printing an image on a portion of a sporting gun, the process carried out by this device not being in accordance with the invention however insofar as the surface on which the image is to be printed is not a geometrically non-developable surface;

Figures 2 and 3 are respectively side and plan exploded views of the Figure 1 device in a different operating position;

Figure 4 is a diagrammatic view in the direction of arrow F4 of Figure 2;

Figures 5 and 6 are respectively side and plan exploded views of the device of Figure 1 in yet another operating position;

Figure 7 is a diagrammatic view in the direction of arrow F7 of Figure 5;

Figure 8 is a diagrammatic view of the device of Figure 1, assembled and ready for the light-exposure phase;

Figure 9 is a diagrammatic view on an enlarged scale of the part indicated at F9 in Figure 8;

Figure 10 is a diagrammatic view in cross-section of a device for carrying out the process according to the invention, shown in its condition for printing images on geometrically non-developable surfaces;

Figure 11 is a diagrammatic view on an enlarged scale of the part indicated at F11 in Figure 10;

Figures 12, 13 and 14 diagrammatically show stages in carrying out the process of the invention using a negative photosensitive resin;

Figures 15, 16 and 17 diagrammatically

show stages in carrying out the process of the invention using a positive photosensitive resin.

Reference will first be made to Figures 1 to 9 to describe a process which is not in accordance with the invention, insofar as the surface of object 3 on which an image is to be printed is not a geometrically non-developable surface. Comparison between Figures 3 and 5 shows that an exposure mask 5 is conformed to the said surface by bending, from the flat condition of Figure 3 to the Figure 5 condition, only in the transverse direction of the object 3. Thus a device for printing the image on the object 3 comprises a support formed by two mutually interlockable parts 1 and 2 between which the object 3 can be firmly immobilised. The parts 1 and 2 are such that, when they are mutually interlocked, immobilising the object 3, they form a generally parallelepiped assembly over which a casing in the form of a flexible transparent PVC sleeve 4 (Figures 2 to 8) can be fitted by being slipped thereonto. Before this, the object 3 has been coated on its surface on which the image is to be printed, with a photosensitive polymer. Also, before setting the sleeve 4 in place to enclose the object 3, the exposure mask 5 is applied to the abovementioned surface, as mentioned above, by bending the mask.

The device also has a valve 6 for connection to a vacuum pump 8 (Figure 8), for instance by rubber tubing 7, for a purpose to be described below.

In the device of Figures 1 to 9, the mask 5 is fixed to the part 1 by a fixing element 9. This arrangement is such that initially the mask 5 is raised (Figures 1 to 3), thus enabling the object 3 and the interlocking part 2 to be set in place, after which the mask 5 is applied to the surface on which the image is to be printed, by being turned down over the top and sides of the object 3 (Figure 5). The sleeve 4 can then easily be set in place, enclosing the two interlocked parts 1 and 2, the object 3 and the mask 5. A sealing gasket 10 is placed between the projecting edges respectively of an end portion 11 of the part 1 and an end frame 12 of the sleeve 4. The valve 6 is so arranged it can form a communication between the vacuum pump 8 and the volume comprised between components 1, 2, 3 and 5 and the sleeve 4.

Thus, when the pump 8 is operated it will produce a reduced pressure within the sleeve 4, which will hold the sleeve firmly against the object, to press the mask against the object.

The device with object 3 is then subjected to light irradiation, the light reaching the above-mentioned mask 5 through the transparent sleeve 4. When the irradiation is sufficient to polymerise the exposed parts of the photosensitive coating on the object 3, the latter is released and subjected to the action of an appropriate chemical bath in order to dissolve the parts of the coating which have been rendered soluble by the action of the light. When a negativ photosensitive polymer is used, it is rendered insoluble at the areas exposed to the light, while when a positive photosensitive polymer is used, the areas not exposed are the insoluble areas. The remaining parts of the coating are hardened by baking.

Reference will now be made to Figures 10 and 11 to describe a process according to the invention. Thus, for printing an image on an object with a surface which is a, geometrically non-developable surface, use is made of an enveloping jacket or casing 13 comprising a flexible, transparent synthetic resin. As shown, the casing 13 comprises two half-shells 13^{1} and 13^{11}, and the mask defining the image to be printed is provided by a coating 14 of a metal which has been vaporised under vacuum on the internal surface of the shells 13^{1} and 13^{11} and then for example etched to form the desired image mask. The casing 13 completely envelops the object 15 and a reduced pressure is produced in the casing 13 by a vacuum pump as described above, so that the mask within the casing 13 is pressed into intimate contact against the said surface over its whole area by the pressing force applied to the mask by the casing, due to the reduced pressure within the casing 13. The device and object are then exposed to light and the polymer coating on the object subjected to the action of an appropriate chemical bath, as described above.

Figures 12 to 14 and Figures 15 to 17 show stages in the process, using a negative or positive photosensitive polymer respectively. In Figures 12 and 15, 16 represents the object, 17 the photosensitive polymer coating, 18 the exposure mask, in this case formed by a film 19, and an emulsion coating 20. The light is directed in the direction of arrows *f*. The polymer coating 18 is opaque as described above, to prevent light from reaching the object through areas of the coating which are not covered by the mask.

Figures 13 and 16 shows the state of the object after the ligh' irradiation stage, and Figures 14 and 17 show the state of the object after the chemical bath, for example after etching with acid.

It will be observed that the parts of the negative photosensitive resin (Figure 13) that have not been subjected to the action of light are dissolved away by the chemical bath, while a positive photosensitive resin (Figure 16) reacts in the reverse manner. The process as described can be applied to any objects, articles or surfaces made of carbon or alloyed steel, tool steel, stainless steel, re-

fractory steel, niobium steel, aluminium, copper, magnesium, molybdenum, zinc, beryllium, nickel, silicon, germanium, or glass, crystal, porcelain and ceramics in general, this list being given purely as an example.

When carrying out the process as described above with reference to the drawings, the cleaning agent used for cleaning the surfaces on which an image is to be printed may be trichlorethylene in vapour phase, and the photosensitive polymer used may be a commercially available product, for example the product known as KMER. According to the case, the polymer used may be chosen from known products such as KPR, KPR2, KPR3, KTFR, KOR, and KPL.

The etching bath used in order to dissolve the parts of the polymer coating which are the more soluble will be of a composition selected in dependence on the polymer used, for example known solvents such as respectively KPR Thinner, KOR Thinner, KMER Thinner, and KFTR Thinner. The surface on which there is the pattern defined by the remaining parts of the polymer coating can be etched for example by spraying onto the surface $FeCl_3$ under pressure at a temperature around 55°C for about 2 minutes.

It will be observerd that after production of the image as described above, the operator can effect a metal deposit on the said surface by electrolysis. An embossed engraving is obtained in this way, although it can also be obtained by placing a negative exposure mask in the support parts (1 and 2 of Figure 1) or utilising a positive-action photosensitive polymer.

Should gold-plating be desired, in the above-mentioned engraving for instance, that operation could be performed by immersion in a chemical or electrolytic bath, before stripping the photosensitive polymer.

It will be appreciated that the object on which the image is to be photographically printed must generally be thoroughly cleaned before coating, in order to ensure a satisfactory bond of the reflection-preventing varnish or the polymer coating to the surface of the object.

WHAT WE CLAIM IS:—

1. A process for photographically printing an image on a non-developable (as hereinbefore defined) surface of an object, which process comprises coating said surface with photosensitive polymer coating to the action of light through an exposure mask provided between said coated surface and a transparent casing wherein the object is enclosed, the exposure mask being pressed into intimate contact with said coating over the whole area thereof by a pressing force which is applied to the exposure mask by the casing and which is produced by a reduced pressure within the casing, and subsequently dissolving away the more soluble parts of the photosensitive polymer coating.

2. A process according to claim 1 wherein said photosensitive polymer coating contains colouring matter which renders it opaque.

3. A process according to claim 2 including the step of cleaning said surface before said photosensitive polymer coating is applied to said surface.

4. A process according to claim 1 wherein said surface is covered with a reflection-preventing varnish prior to the step of applying said photosensitive polymer coating.

5. A process according to claim 4 including the step of cleaning said surface before said varnish is applied to said surface.

6. A process according to any one of the preceding claims wherein said exposure mask is provided on the internal surface of the casing.

7. A process for photographically printing an image on a non-developable (as hereinbefore defined) surface of an object, the process being substantially as hereinbefore described with reference to Figures 10 to 14, or Figures 10, 11 and 15 to 17, of the accompanying drawings.

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

Fig. 1

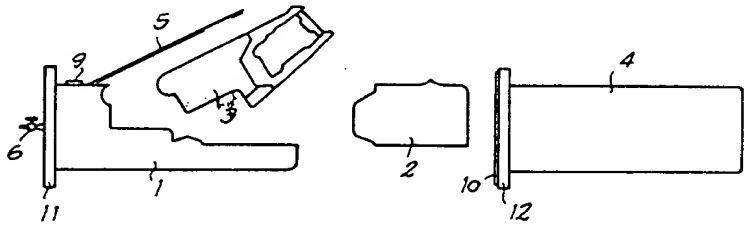


Fig. 2

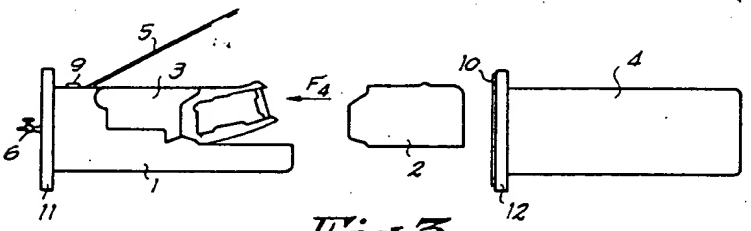


Fig. 3

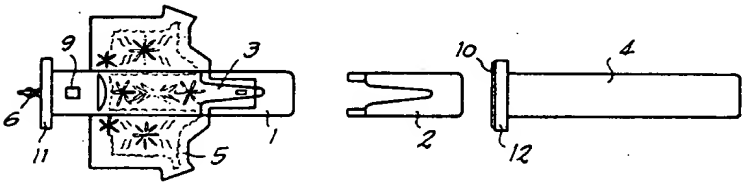
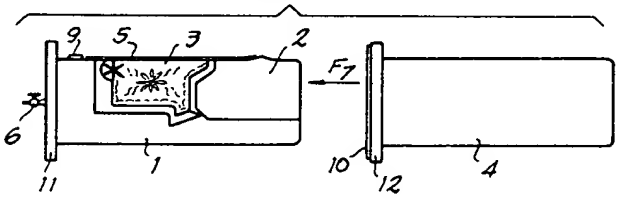


Fig. 5



1472462 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 2

Fig. 6

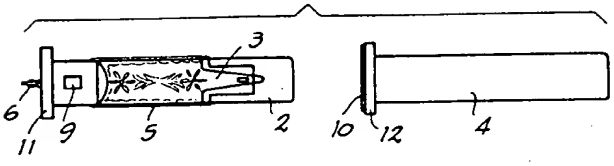


Fig. 8

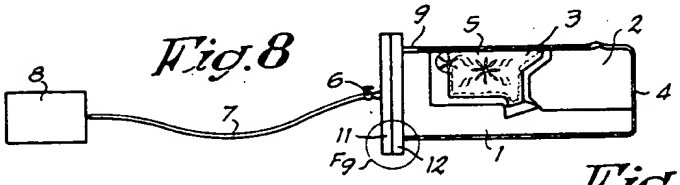


Fig. 4

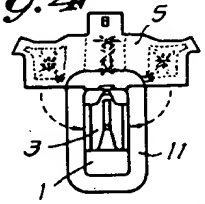


Fig. 7

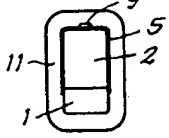
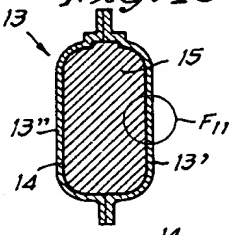


Fig. 10



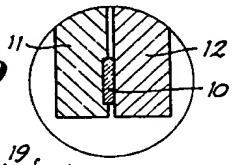


Fig. 9

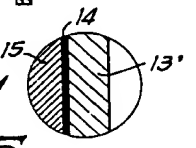


Fig. 11

Fig. 12

Fig. 15

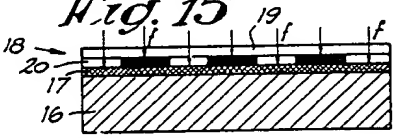


Fig. 13

Fig. 16

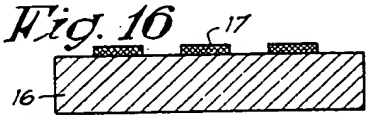


Fig. 14

Fig. 17